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Table of Contents

1 Scope of this Document

This document specifies requirements on the module PWM Driver.

Constraints

First scope for specification of requirements on basic software module is systems which are not safety relevant. For this reason safety requirements are assigned to medium priority.

2 How to read this document

Each requirement has its unique identifier starting with the prefix "BSW" (for "Basic Software"). For any review annotations, remarks or questions, please refer to this unique ID rather than chapter or page numbers!

2.1 Conventions used

In requirements, the following specific semantics are used (taken from Request for Comment RFC 2119 from the Internet Engineering Task Force IETF)

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119. Note that the requirement level of the document in which they are used modifies the force of these words.

- MUST: This word, or the terms "REQUIRED" or "SHALL", mean that the definition is an absolute requirement of the specification.
- MUST NOT: This phrase, or the phrase „SHALL NOT", means that the definition is an absolute prohibition of the specification.
- SHOULD: This word, or the adjective "RECOMMENDED", mean that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- SHOULD NOT: This phrase, or the phrase "NOT RECOMMENDED" mean that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
- MAY: This word, or the adjective „OPTIONAL", means that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation, which does not include a particular option, MUST be prepared to interoperate with another implementation, which does include the option, though perhaps with reduced functionality. In the same vein an implementation, which does include a particular option, MUST be prepared to interoperate with another implementation, which does not include the option (except, of course, for the feature the option provides.)

2.2 Requirements structure

Each module specific chapter contains a short functional description of the Basic Software Module. Requirements of the same kind within each chapter are grouped under the following headlines (where applicable):

Functional Requirements:
- Configuration (which elements of the module need to be configurable)
- Initialisation
- Normal Operation
- Shutdown Operation
- Fault Operation
- ...

Non-Functional Requirements:
- Timing Requirements
- Resource Usage
- Usability
- Output for other WPs (e.g. Description Templates, Tooling,...)
- ...

3 Acronyms and abbreviations

Acronyms and abbreviations that have a local scope are not contained in the AUTOSAR glossary. These must appear in a local glossary.

Acronym:	Description:
CS	Chip Select
DIO	Digital Input Output
ECU	Electric Control Unit
DMA	Direct Memory Access
HIS	Herstellerinitiative Software
ICU	Input Capture Unit
MAL	Old name of Microcontroller Abstraction Layer (replaced by MCAL because 'MAL' is a french term meaning 'bad')
MCAL	Microcontroller Abstraction Layer
MCU	Microcontroller Unit
MISO	Master Input Slave Output
MMU	Memory Management Unit
MOSI	Master Output Slave Input
Master	A device controlling other devices (slaves, see below)
Slave	A device being completely controlled by a master device
NMI	Non Maskable Interrupt
OS	Operating System
PLL	Phase Locked Loop
PWM	Pulse Width Modulation
RX	Reception (in the context of bus communication)
SPAL	The name of this working group
SFR	Special Function Register
RTE	RunTime Environment

Abbreviation:	Description:
STD	Standard
REQ	Requirement
UNINIT	Uninitialized (= not initialized)

As this is a document from professionals for professionals, all other terms are expected to be known.

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4 Requirement Specification

4.1 PWM Driver

4.1.1 Functional Overview

This specification specifies the functionality, API and the configuration of the AUTOSAR Basic Software module Pwm driver.

Each PWM channel is linked to a hardware PWM which belongs to the microcontroller. The type of the PWM signal (for example center Align, left Align, Etc..) is not defined within this specification and is left up to the implementation.

The driver provides services for initialization and control of the microcontroller internal PWM stage (pulse width modulation). The PWM module generates pulses with variable pulse width. It allows the selection of the duty cycle and the signal period time.

4.1.2 Functional Requirements

4.1.2.1 General

4.1.2.1.1 [BSW12459] PWM duty cycle scaling

Initiator:	SVDO
Date:	17.02.2005
Short Description:	PWM duty cycle scaling
Type:	New
Importance:	High
Description:	The PWM Driver shall provide the following scaling scheme for duty cycle: • 0 = 0% • 0x8000 = 100% 0x8000 gives the highest resolution while allowing 100% duty cycle to be represented with a 16 bit value.
Rationale:	The value 0x8000 (32768) is chosen because the following calculation can be implemented efficiently.
Use Case:	Source code example: AbsoluteDutyCycle = ((uint32)AbsolutePeriodTime * RelativeDutyCycle) >> 15;
Dependencies:	[BSW12383] Resolution of duty cycle
Conflicts:	--
Supporting Material:	--

4.1.2.1.2 [BSW12383] Resolution of duty cycle

Initiator:	Hella
Date:	12.11.2004

Short Description:	Resolution of duty cycle
Type:	Changed (resolution changed from 0.2 % to 16 bit value)
Importance:	High
Description:	The PWM driver shall provide a 16 bit interface to set the duty cycle.
Rationale:	--
Use Case:	--
Dependencies:	The duty cycle is always the active level of the signal (High or low, depends on idle level configuration, see [BSW12293])
Conflicts:	--
Supporting Material:	--

4.1.2.2 Configuration

4.1.2.2.1 [BSW12375] PWM global configuration

Initiator:	Hella
Date:	12.11.2004
Short Description:	PWM global configuration
Type:	New
Importance:	Medium
Description:	The PWM Driver shall allow the module wide configuration of the following parameters: • Number of PWM channels
Rationale:	Basic configuration
Use Case:	--
Dependencies:	--
Conflicts:	--
Supporting Material:	--

4.1.2.2.2 [BSW12293] Configuration of PWM channel properties

Initiator:	WP4.2.2.1.12
Date:	07.02.2006
Short Description:	Configuration of PWM channel properties
Type:	Changed (Rfc 4053: and bug 5523, bug 4962 and #9606)
Importance:	High

Description:	The PWM driver shall allow the static configuration of the following options for each PWM channel.
	Mandatory parameters:
	• assigned HW channel
	• default value for period
	• default value for duty cycle
	• Polarity (high or low)
	• idle state (duty cycle = 0%) high or low
	• Type of Channel:
	   - Fixed Period
	   - Fixed Period, shifted (if supported by hardware)
	   - Variable Period
	
	Optional parameters (if supported by hardware):

	• channel phase shift
	• Reference channel for phase shift
	• microcontroller specific channel properties
Rationale:	Basic channel configuration.
Use Case:	Channel phase shift: to avoid EMC problems
Dependencies:	[BSW12383] Resolution of duty cycle [BSW12459] PWM duty cycle scaling
Conflicts:	--
Supporting Material:	BMW Specification MCAL V1.0a, MAL13.1.4 The idle level configuration covers the 'active phase' requirement from Hella.

4.1.2.2.3 [BSW12378] Assign notification to edges

Initiator:	WP4.2.2.1.12
Date:	16.11.2005
Short Description:	Assign notification to edges
Type:	Changed (modified due to bug #4054)
Importance:	High
Description:	The PWM driver shall be able to assign notification to each edges of the PWM-signal. This notification shall be statically configurable.
Rationale:	--
Use Case:	PWM edge triggered ADC conversions PWM signal diagnosis
Dependencies:	[BSW12299] [BSW12293]
Conflicts:	--
Supporting Material:	--

4.1.2.2.4 [BSW12379] Frequency of PWM channel groups

Initiator:	Hella
Date:	12.11.2004
Short Description:	Frequency of PWM channel groups
Type:	Changed (channels -> channel groups) and RFC #14638)
Importance:	High
Description:	All PWM Channels which work with the same MCU Timer shall have either the same frequency or independent frequencies.
Rationale:	Depending on the microcontroller hardware it can be possible that not every PWM channel has it's own timer. In this case the PWM channels have to share one timer. The frequencies of the PWM channels have to be either the same or independent from the HW timer frequency. The configuration has to take this into account.
Use Case:	--
Dependencies:	--
Conflicts:	--
Supporting Material:	--

4.1.2.2.5 [BSW12389] Frequency of PWM channels

Initiator:	Delphi
Date:	15.11.2004
Short Description:	Frequency of PWM channel
Type:	Changed (use case added)
Importance:	High
Description:	The PWM driver shall allow only static configuration of the frequency for some PWM channels.
Rationale:	--
Use Case:	The frequency of some PWM channels shall not be changeable during runtime
Dependencies:	Requirement [BSW12293], configuration of the Type of channel.
Conflicts:	--
Supporting Material:	--

4.1.2.3 Initialization

4.1.2.3.1 [BSW12380] Initialization of PWM driver

Initiator:	Hella
Date:	12.11.2004
Short Description:	Initialization of PWM driver
Type:	Changed (split of requirement)
Importance:	High
Description:	By initializing the PWM driver, all PWM-channels are started.
Rationale:	--
Use Case:	--
Dependencies:	--
Conflicts:	--
Supporting Material:	--

4.1.2.3.2 [BSW12381] De-Initialization of PWM driver

Initiator:	WP4.2.2.1.12
Date:	07.12.2005
Short Description:	De-Initialization of PWM driver
Type:	Changed (bug 4962)
Importance:	High
Description:	By de-initializing the PWM driver, all PWM-channels shall be stopped.The state of the PWM outputs shall be configurable.
Rationale:	--
Use Case:	--
Dependencies:	[BSW12163] Driver module deinitialization [BSW12293] Configuration of PWM channel properties
Conflicts:	--
Supporting Material:	--

4.1.2.4 Normal Operation

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- AUTOSAR confidential -

4.1.2.4.1 [BSW12295] Set PWM duty cycle

Initiator:	WP4.2.2.1.12
Date:	27.07.2006
Short Description:	Set PWM duty cycle
Type:	Changed (bug 4962, bug 11784)
Importance:	High
Description:	The PWM driver shall provide a service for setting the duty cycle of a selected channel. The parameters shall be • PWM channel • PWM duty cycle (range: 0..100%; 0% = Inverted polarity level, 100% = Polarity level, no spikes allowed)
Rationale:	Basic functionality.
Use Case:	--
Dependencies:	[BSW12459] PWM duty cycle scaling – [BSW12383] Resolution of duty cycle
Conflicts:	--
Supporting Material:	BMW Specification MCAL V1.0a, MAL13.x

4.1.2.4.2 [BSW12382] Update of PWM duty cycle

Initiator:	VALEO, Hella
Date:	02.03.2005
Short Description:	Update of PWM duty cycle
Type:	New
Importance:	Medium
Description:	The PWM Driver shall wait to the end of the signal period to update the duty cycle of a PWM signal. This feature shall be configurable.
Rationale:	Duty cycle not changed during a period. Duty cycle changes during a period can lead to undesired artefacts on the output signal (insertion of one pulse that is too short/too long). I know this as "buffered/unbuffered PWM output operation" (Freescale HC08). Buffered operation (which avoids those dirt effects) requires 2 registers instead of one.
Use Case:	--
Dependencies:	--
Conflicts:	--
Supporting Material:	--

4.1.2.4.3 [BSW12358] Set PWM output state

Initiator:	WP4.2.2.1.12
Date:	07.12.2005
Short Description:	Set PWM output
Type:	Changed (bug 4962)
Importance:	High
Description:	The PWM driver shall be capable to set the output of selected channel to a given state immediately.
Rationale:	Allow disabling a PWM output.

Use Case:	Brake slope of an MOSFET controlled DC motor: The duty cycle is reduced step wise within a slope. After having reached the target brake duty cycle value (e.g. 35 %), the MOSFET is switched off by setting the duty cycle immediately to 0%.
Dependencies:	--
Conflicts:	--
Supporting Material:	This shall be a separate interface

4.1.2.4.4 [BSW12385] Get current state of PWM Channel output

Initiator:	WP4.2.2.1.12
Date:	07.12.2005
Short Description:	Get current state of PWM Channel output.
Type:	Changed (bug 4962)
Importance:	High
Description:	The PWM driver shall provide a service to get the state of a PWM channel (high or low) if supported by hardware.
Rationale:	Allow to read back the state of the PWM for diagnosis.
Use Case:	Diagnostic of low frequency PWM outputs. Edge detection using polling when modulating Explanation of Hella on 17.02.2005: A power stage is connected to a PWM output pin. The diagnosis output of the power stage is connected to an ADC input pin. The evaluation of the diagnosis output shall be started after the requested level appears on the PWM output pin.
Dependencies:	--
Conflicts:	--
Supporting Material:	--

4.1.2.4.5 [BSW12297] Set PWM period

Initiator:	BMW
Date:	25.09.2004
Short Description:	Set PWM period
Type:	Changed (stability of duty cycle added)
Importance:	High

Description:	The PWM driver shall provide a service for setting the period of a selected channel. The parameters shall be • PWM channel • PWM period • PWM duty cycle This functionality is available only for the PWM channel configured as type of channels "Variable Period".
Rationale:	The PWM duty cycle parameter is necessary to maintain the consistency between frequency and duty cycle. Otherwise, the effective duty cycle would change when the period is changed or the PWM driver would have to recalculate the new duty cycle by itself.
Use Case:	• Kojak siren with stable 50% duty cycle square wave • LED blinking with different frequencies
Dependencies:	[BSW12459] PWM duty cycle scaling
Conflicts:	--
Supporting Material:	BMW Specification MCAL V1.0a, MAL13.8.0 Kojak movies (in case you do not know Kojak)

4.1.2.4.6 [BSW12299] Activation of PWM edge notification

Initiator:	WP4.2.2.1.12
Date:	12.09.2005
Short Description:	Activation of PWM edge notification
Type:	Changed (Rfc 4053: Use cases updated and move configuration requirements in BSW12293)
Importance:	High
Description:	The PWM driver shall allow to enable/disable the PWM edges notification during runtime..
Rationale:	Allow synchronization with other modules
Use Case:	PWM edge triggered ADC conversions PWM signal diagnosis Update of duty cycle using the notification in case of single buffer
Dependencies:	[BSW12293] Configuration of PWM channel properties
Conflicts:	--
Supporting Material:	HIS Specification I/O Driver V2.1.3

4.1.3 Non-Functional Requirements (Qualities)

4.1.3.1 [BSW12386] No PWM emulation

Initiator:	Hella
Date:	12.11.2004
Short Description:	No PWM emulation
Type:	New
Importance:	High
Description:	The PWM driver shall only work with the PWM pins on the MCU. The PWM driver shall not cover a PWM emulation on general purpose I/O.
Rationale:	--
Use Case:	--

Dependencies:	--
Conflicts:	--
Supporting Material:	--

5 Related Documentation

5.1 Deliverables of AUTOSAR

[1] List of Basic Software Modules
https:/svn2.autosar.org/repos2/22_Releases
AUTOSAR_BasicSoftwareModules.pdf

[2] Layered Software Architecture
https:/svn2.autosar.org/repos2/22_Releases
AUTOSAR_LayeredSoftwareArchitecture.pdf

[3] General Requirements on Basic Software Modules
https:/svn2.autosar.org/repos2/22_Releases
AUTOSAR_SRS_General.pdf

[4] General Requirements on SPAL
https:/svn2.autosar.org/repos2/22_Releases
AUTOSAR_SRS_SPAL_General.pdf